

CLAIMS

We Claim:

1. A method of operating a micromirror device that comprises a movable mirror plate and an electrode formed on a substrate for driving the mirror plate, the method comprising:
 - applying a first voltage to the mirror plate and a second voltage to the electrode such that voltage difference between the mirror plate and the electrode drives the mirror plate to rotate relative to the substrate; and
 - applying a third voltage to the mirror plate, and a fourth voltage to the electrode such that the voltage difference between the mirror plate and the electrode drives the mirror plate to rotate relative to the substrate, wherein difference between the third voltage and the fourth voltage has an opposite polarity to that between the first voltage and the second voltage.
2. The method of claim 1, wherein the first voltage and the second voltage are applied in response to a first subsequence of a sequence of actuation signals, and the third voltage and the fourth voltage are applied in response to a second subsequence of the sequence of actuation signals.
3. The method of claim 2, wherein the actuation signal corresponds to an ON state of the micromirror, wherein the ON state is defined as a state such that the micromirror reflects light into a projection lens for producing a bright pixel of an image on a display target.
4. The method of claim 2, wherein the actuation signal corresponds to an OFF state of the micromirror, wherein the OFF state is defined as a state such that the micromirror reflects light away from a projection lens for producing a dark pixel of an image on a display target.
5. The method of claim 2, wherein the first subsequence and the second subsequence are interleaved.
6. The method of claim 2, wherein the second subsequence is determined such that a predetermined number of applications of the first and second voltages is between two consecutive applications of the third and fourth voltages.

7. The method claim 1, wherein the second subsequence of the sequence of the actuation signals has a frequency more than a predetermined frequency, wherein the frequency is defined as the number of actuation signals in the subsequence per second.
8. The method of claim 7, wherein the critical frequency is determined in accordance with a perceptual ability of human eyes.
9. The method of claim 1, wherein the fourth voltage is zero.
10. The method of claim 1, wherein the step of applying the third voltage and the fourth voltage further comprises:
grounding the electrode.
11. The method of claim 1, wherein the step of applying the third voltage and the fourth voltage further comprises:
grounding the mirror plate.
12. The method of claim 1, wherein the third voltage has an opposite polarity to the first voltage.
13. The method of claim 1, wherein the fourth voltage has an opposite polarity to the second voltage.
14. The method of claim 1, wherein the difference between the first voltage and the second voltage is from 15 volts to 80 volts.
15. The method of claim 1, wherein the difference between the first voltage and the second voltage is from 25 volts to 50 volts.
16. The method of claim 1, wherein the difference between the first voltage and the second voltage is around 30 volts.

17. The method of claim 1, wherein the difference between the third voltage and the fourth voltage is from 15 volts to 80 volts.
18. The method of claim 1, wherein the difference between the third voltage and the fourth voltage is from 25 volts to 50 volts.
19. The method of claim 1, wherein the difference between the third voltage and the fourth voltage is around 30 volts.
20. The method of claim 1, wherein the first voltage and the second voltage are from 0 to 100 volts.
21. The method of claim 1, wherein the first voltage and the second voltage are from 0 to 50 volts.
22. The method of claim 1, wherein the first voltage and the second voltage are around 30 volts.
23. The method of claim 1, wherein the third voltage and the fourth voltage are from 0 to 100 volts.
24. The method of claim 1, wherein the third voltage and the fourth voltage are from 0 to 50 volts.
25. The method of claim 1, wherein the third voltage and the fourth voltage are around 50 volts.
26. The method of claim 1, wherein the second subsequence of the sequence of the actuation signal has a frequency higher than 30 Hz.
27. The method of claim 1, wherein the rotation of the mirror plate driven by the voltage difference between the third voltage and the fourth voltage is along a rotation direction that is

the same as that of the mirror plate driven by the voltage difference between the first voltage and the second voltage.

28. The method of claim 1, wherein the application of the first voltage and the second voltage and the application of the third voltage and the fourth voltage are performed alternatively.

29. The method of claim 1, wherein the application of the first voltage and the second voltage and the application of the third voltage and the fourth voltage are performed once per video frame.

30. The method of claim 1, wherein the application of the first voltage and the second voltage and the application of the third voltage and the fourth voltage are performed once per time interval determined by a time interval between two consecutive color segments of a color wheel used by the display system in producing a color image.

31. The method of claim 1, wherein the application of the first voltage and the second voltage and the application of the third voltage and the fourth voltage are performed once per time interval determined by a wave-segment of a pulse-width-modulation waveform used in producing the grayscale of the image or the video frame.

32. The method of claim 1, wherein the application of the first voltage and the second voltage and the application of the third voltage and the fourth voltage are performed at the beginning of displaying the image or the video frame.

33. A method of operating a display system that comprises an array of micromirrors, each micromirror comprising a mirror plate and an electrode for rotating the mirror plate, the method comprising:

directing a light beam onto the micromirror array; and
selectively reflecting the light beam into an optical element for producing an image or a video frame on a display target, which further comprises:

selecting one or more micromirrors from the micromirror array according to a gray scale of the image or the video frame;

applying a first voltage to the mirror plate and a second voltage to the electrode of the selected micromirror such that voltage difference between the mirror plate and the electrode drives the mirror plate to rotate to one of the ON state and OFF state of the micromirror relative to the substrate at one time; and

applying a third voltage to the mirror plate, and a fourth voltage to the electrode of the selected micromirror such that the voltage difference between the mirror plate and the electrode drives the mirror plate to rotate relative to the substrate, wherein difference between the third voltage and the fourth voltage has an opposite polarity to that between the first voltage and the second voltage.

34. The method of claim 33, wherein step of applying the first voltage to the mirror plate and the second voltage to the electrode further comprises:

maintaining the first and second voltages on the mirror plate and the electrode for a time interval determined by the grayscale of the image or the video according to a pulse-width-modulation technique.

35. The method of claim 33, wherein step of applying the third voltage to the mirror plate and the fourth voltage to the electrode further comprises:

maintaining the third and fourth voltages on the mirror plate and the electrode for a time interval determined by the grayscale of the image or the video according to a pulse-width-modulation technique

36. The method of claim 33, wherein the first voltage and the second voltage are applied in response to a first subsequence of a sequence of actuation signals, and the third voltage and the fourth voltage are applied in response to a second subsequence of the sequence of actuation signals.

37. The method of claim 34, wherein the actuation signal corresponds to an ON state of the micromirror, wherein the ON state is defined as a state such that the micromirror reflects light into a projection lens for producing a bright pixel of an image on a display target.
38. The method of claim 34, wherein the actuation signal corresponds to an OFF state of the micromirror, wherein the OFF state is defined as a state such that the micromirror reflects light away from a projection lens for producing a dark pixel of an image on a display target.
39. The method of claim 34, wherein the first subsequence and the second subsequence are interleaved.
40. The method of claim 34, wherein the second subsequence is determined such that a predetermined number of applications of the first and second voltages is between two consecutive applications of the third and fourth voltages.
41. The method of claim 34, wherein the second subsequence of the sequence of the actuation signals has a frequency more than a predetermined frequency, wherein the frequency is defined as the number of actuation signals in the subsequence per second.
42. The method of claim 39, wherein the frequency is determined in accordance with a perceptual ability of human eyes.
43. The method of claim 33, wherein the fourth voltage is zero.
44. The method of claim 33, wherein the step of applying the third voltage and the fourth voltage further comprises:
grounding the electrode.
45. The method of claim 33, wherein the step of applying the third voltage and the fourth voltage further comprises:
grounding the mirror plate.

46. The method of claim 33, wherein the third voltage has an opposite polarity to the first voltage.
47. The method of claim 33, wherein the fourth voltage has an opposite polarity to the second voltage.
48. The method of claim 33, wherein the difference between the first voltage and the second voltage is from 15 volts to 80 volts.
49. The method of claim 33, wherein the difference between the first voltage and the second voltage is from 25 volts to 50 volts.
50. The method of claim 33, wherein the difference between the first voltage and the second voltage is around 30 volts.
51. The method of claim 33, wherein the difference between the third voltage and the fourth voltage is from 15 volts to 80 volts.
52. The method of claim 33, wherein the difference between the third voltage and the fourth voltage is from 25 volts to 50 volts.
53. The method of claim 33, wherein the difference between the third voltage and the fourth voltage is around 30 volts.
54. The method of claim 33, wherein the first voltage and the second voltage are from 0 to 100 volts.
55. The method of claim 33, wherein the first voltage and the second voltage are from 0 to 50 volts.
56. The method of claim 33, wherein the first voltage and the second voltage are around 30 volts.

57. The method of claim 33, wherein the third voltage and the fourth voltage are from 0 to 100 volts.
58. The method of claim 33, wherein the third voltage and the fourth voltage are from 0 to 50 volts.
59. The method of claim 33, wherein the third voltage and the fourth voltage are around 50 volts.
60. The method of claim 33, wherein the second subsequence of the sequence of the actuation signal has a frequency higher than 30 Hz.
61. The method of claim 33, wherein the rotation of the mirror plate driven by the voltage difference between the third voltage and the fourth voltage is along a rotation direction that is the same as that of the mirror plate driven by the voltage difference between the first voltage and the second voltage.
62. The method of claim 33, wherein the application of the first voltage and the second voltage and the application of the third voltage and the fourth voltage are performed alternatively.
63. The method of claim 33, wherein the application of the first voltage and the second voltage and the application of the third voltage and the fourth voltage are performed once per video frame.
64. The method of claim 33, wherein the application of the first voltage and the second voltage and the application of the third voltage and the fourth voltage are performed once per time interval determined by a time interval between two consecutive color segments of a color wheel used by the display system in producing a color image.

65. The method of claim 33, wherein the application of the first voltage and the second voltage and the application of the third voltage and the fourth voltage are performed once per time interval determined by a wave-segment of a pulse-width-modulation waveform used in producing the grayscale of the image or the video frame.

66. The method of claim 33, wherein the application of the first voltage and the second voltage and the application of the third voltage and the fourth voltage are performed at the beginning of displaying the image or the video frame.

67. A display system, comprising:

a light source;
an array of micromirrors, each micromirror comprises a mirror plate and an electrode associated with the mirror plate for driving the mirror plate to rotate;

a voltage controller that: a) sets the mirror plate to a first voltage and the electrode to a second voltage such that the difference between the first voltage and the second voltage drives the mirror plate to rotate; b) sets the mirror plate to a second voltage and the electrode to a fourth voltage such that the difference between the third voltage and the fourth voltage drives the mirror plate to rotate; and c) wherein the difference between the first voltage and second voltage has an opposite polarity than that between the third voltage and the fourth voltage; and

a plurality of optical elements for directing light from the light source onto the array of micromirrors and directing the reflected light from the micromirrors onto a display target for producing an image or a video frame.

68. The display system of claim 67, wherein the first voltage and the second voltage are applied in response to a first subsequence of a sequence of actuation signals, and the third voltage and the fourth voltage are applied in response to a second subsequence of the sequence of actuation signals.

69. The display system of claim 68, wherein the actuation signal corresponds to an ON state of the micromirror, wherein the ON state is defined as a state such that the micromirror

reflects light into a projection lens for producing a bright pixel of an image on a display target.

70. The display system of claim 68, wherein the actuation signal corresponds to an OFF state of the micromirror, wherein the OFF state is defined as a state such that the micromirror reflects light away from a projection lens for producing a dark pixel of an image on a display target.

71. The display system of claim 68, wherein the first subsequence and the second subsequence are interleaved.

72. The display system of claim 68, wherein the second subsequence is determined such that a predetermined number of applications of the first and second voltages is between two consecutive applications of the third and fourth voltages.

73. The display system claim 67, wherein the second subsequence of the sequence of the actuation signals has a frequency more than a predetermined frequency, wherein the frequency is defined as the number of actuation signals in the subsequence per second.

74. The display system of claim 73, wherein the predetermined frequency is determined in accordance with a perceptual ability of human eyes.

75. The display system of claim 67, wherein the difference fourth voltage is zero.

76. The display system of claim 67, wherein the voltage controller further comprises: a means for grounding the electrode.

77. The display system of claim 67, wherein the voltage controller further comprises: a means for grounding the mirror plate.

78. The display system of claim 67, wherein the third voltage has an opposite polarity to the first voltage.

79. The display system of claim 67, wherein the fourth voltage has an opposite polarity to the second voltage.
80. The display system of claim 67, wherein the difference between the first voltage and the second voltage is from 15 volts to 80 volts.
81. The display system of claim 67, wherein the difference between the first voltage and the second voltage is from 25 volts to 50 volts.
82. The display system of claim 67, wherein the difference between the first voltage and the second voltage is around 30 volts.
83. The display system of claim 67, wherein the difference between the third voltage and the fourth voltage is from 15 volts to 80 volts.
84. The display system of claim 67, wherein the difference between the third voltage and the fourth voltage is from 25 volts to 50 volts.
85. The display system of claim 67, wherein the difference between the third voltage and the fourth voltage is around 30 volts.
86. The display system of claim 67, wherein the first voltage and the second voltage are from 0 to 100 volts.
87. The display system of claim 67, wherein the first voltage and the second voltage are from 0 to 50 volts.
88. The display system of claim 67, wherein the first voltage and the second voltage are around 30 volts.

89. The display system of claim 67, wherein the third voltage and the fourth voltage are from 0 to 100 volts.
90. The display system of claim 67, wherein the third voltage and the fourth voltage are from 0 to 50 volts.
91. The display system of claim 67, wherein the third voltage and the fourth voltage are around 50 volts.
92. The display system of claim 67, wherein the second subsequence of the sequence of the actuation signal has a frequency higher than 30 Hz.
93. A display system, comprising:
 - a light source;
 - an array of micromirrors, each micromirror comprises a mirror plate and an electrode associated with the mirror plate for driving the mirror plate to rotate;
 - a voltage controller that further comprise:
 - a means for setting the mirror plate to a first voltage and the electrode to a second voltage such that the difference between the first voltage and the second voltage drives the mirror plate to rotate;
 - a means for setting the mirror plate to a third voltage and the electrode to a fourth voltage such that the difference between the third voltage and the fourth voltage drives the mirror plate to rotate; and
 - wherein the difference between the first voltage and second voltage has an opposite polarity than that between the third voltage and the fourth voltage; and
 - a plurality of optical elements for directing light from the light source onto the array of micromirrors and directing the reflected light from the micromirrors onto a display target for producing an image or a video frame.
94. A computer-readable medium having computer-executable instructions for performing steps of controlling spatial light modulations of an array of micromirrors used in a

display system, wherein each micromirror of the array comprises a movable mirror plate and an electrode driving the mirror plate to rotate, the steps comprising:

selecting one or more micromirrors from the micromirror array according to a gray scale of an image or a video frame;

applying a first voltage to the mirror plate and a second voltage to the electrode of the selected micromirror such that voltage difference between the mirror plate and the electrode drives the mirror plate to rotate to one of the ON state and OFF state of the micromirror relative to the substrate at one time; and

applying a third voltage to the mirror plate and a fourth voltage to the electrode of the selected micromirror such that the voltage difference between the mirror plate and the electrode drives the mirror plate to rotate relative to the substrate, wherein difference between the third voltage and the fourth voltage has an opposite polarity to that between the first voltage and the fourth voltage at another time.

95. A projector comprising:

a light source;

a spatial light that selectively reflecting light from the light source modulator that comprises an array of micromirrors, each micromirror having a movable mirror plate and an electrode driving the mirror plate to rotate;

a controller having computer-executable instructions for performing steps of controlling the selective reflection of the spatial light modulator, the steps comprising:

selecting one or more micromirrors from the micromirror array according to a gray scale of an image or a video frame;

applying a first voltage to the mirror plate and a second voltage to the electrode of the selected micromirror such that voltage difference between the mirror plate and the electrode drives the mirror plate to rotate to one of the ON state and OFF state of the micromirror relative to the substrate at one time; and

applying a third voltage to the mirror plate and a fourth voltage to the electrode of the selected micromirror such that the voltage difference between the mirror plate and the electrode drives the mirror plate to rotate relative to the substrate, wherein difference between the third voltage and the fourth

voltage has an opposite polarity to that between the first voltage and the second voltage; and

a plurality of optical elements for directing light from the light source onto the spatial light modulator and projecting the reflected light from the spatial light modulator onto a display target of the projector.